Mass Spectrum dependence of Higgs-mediated μ-e Transition in the MSSM

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Mass Spectrum dependence of Higgs-mediated μ-e Transition in the MSSM

- CLFV in the MSSM
- The Higgs mediated LFV
- Conclusion

cLFV in the New Physics

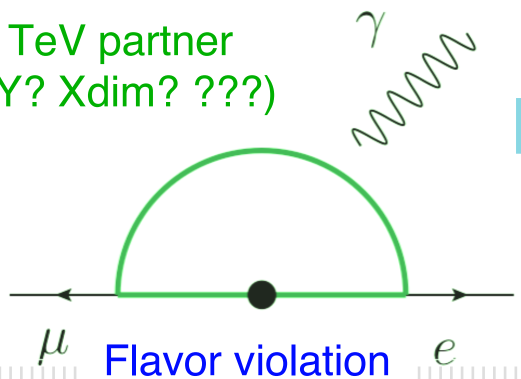
In the SM, there is **no LFV**. However,

Discovery of neutrino oscillation (SK,KamLand,SNO,K2K,etc,,,)

TeV physics requires partner of SM particles (SUSY? Xdim? LH???)

$\mu \rightarrow e\,\gamma$ decay

some TeV partner
(SUSY? Xdim? ???)



Flavor violation
(from ν oscillation ??)

$$\mathrm{BR}(\mu \to e\gamma) \sim \frac{\alpha}{4\pi} \frac{m_W^4}{(\Lambda \sim \mathrm{TeV})^4} \Delta_{\mu e}^2 F_{\mathrm{NP}}$$

Perhaps, detectable?

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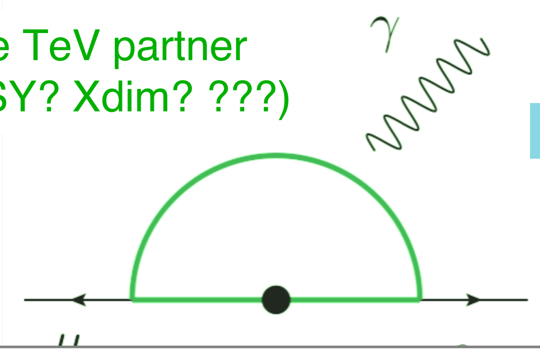


$$\mathrm{BR}(\mu \to e\gamma) \sim \frac{\alpha}{4\pi} \frac{m_W^4}{(\Lambda \sim \mathrm{TeV})^4} \Delta_{\mu e}^2 F_{\mathrm{NP}}$$

cLFV process is clean signature of beyond the SM!

cLFV in the MSSM

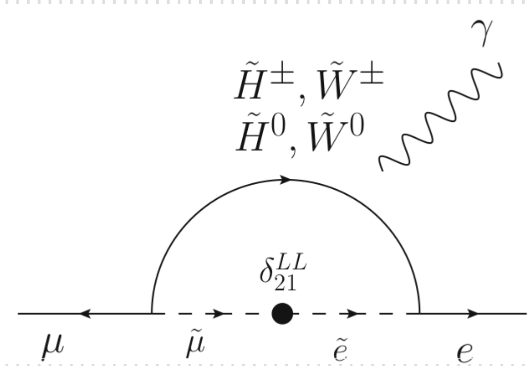
- In the SUSY models, these cLFV are induced by
  - Ordinary slepton / gaugino exchange
  - Higgs exchange (Babu&Kolda, 2000, 2002)

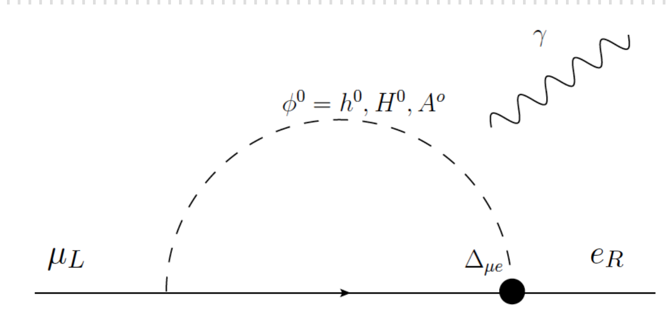
    (Masiero et al, Brignole & Rossi, Ellis et al, etc,,,)

Gaugino LFV

Higgs LFV

$\mu \to e\,\gamma$





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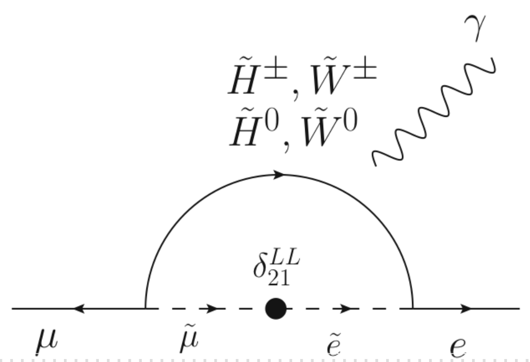
  - Ordinary slepton / gaugino exchange
  - Higgs exchange (Babu&Kolda, 2000, 2002)

    (Masiero et al, Brignole & Rossi, Ellis et al, etc,,,)
- Especially μ→e, two-loop effects can be dominant

  (Paradisi, 2005, 2006)

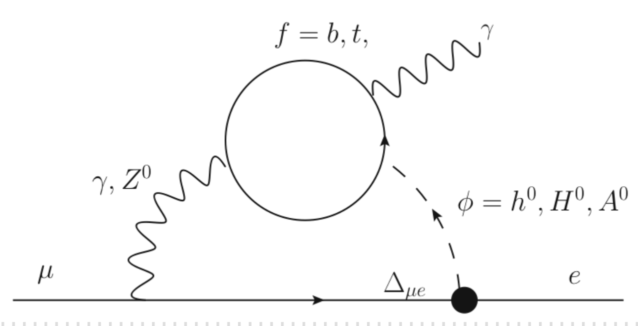
$\mu \to e\,\gamma$

Gaugino LFV



$\ll$

Higgs LFV



cLFV in the MSSM

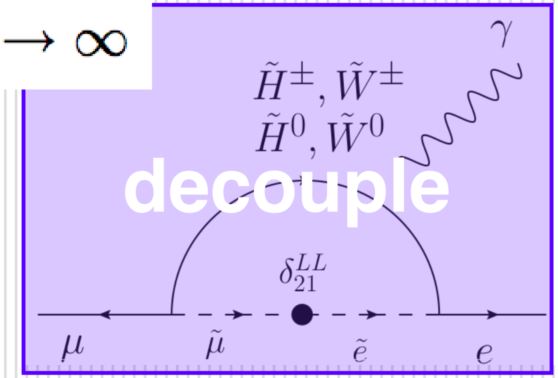
- We calculate this two-loop (Barr-Zee) dgms. and BR(μAl→eAl) / BR(μ→eγ) in some mass parameters.
  - It is considered that the Higgs effect becomes dominant when SUSY particles are decouple (non decoupling effect).

Gaugino LFV

Higgs LFV

$M_{\mathrm{SUSY}} \to \infty$

$\mu \to e\,\gamma$



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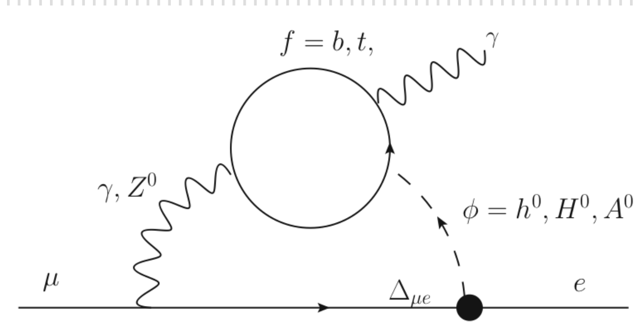
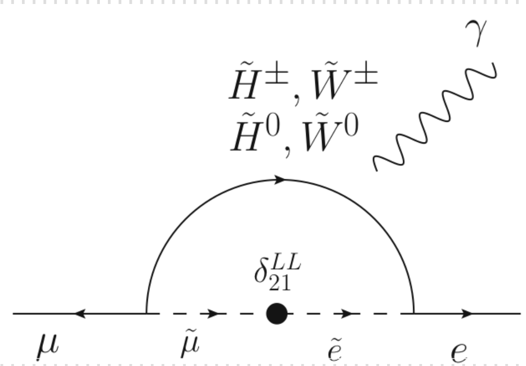


cLFV in the MSSM

- We calculate this two-loop (Barr-Zee) dgms. and BR(μAl→eAl) / BR(μ→eγ) in some mass parameters.
  - It is considered that the Higgs effect becomes dominant when SUSY particles are decouple (non decoupling effect).
- However, if there are destructive interference, it is necessary to consider the Higgs LFV effect.

$\mu \to e\,\gamma$

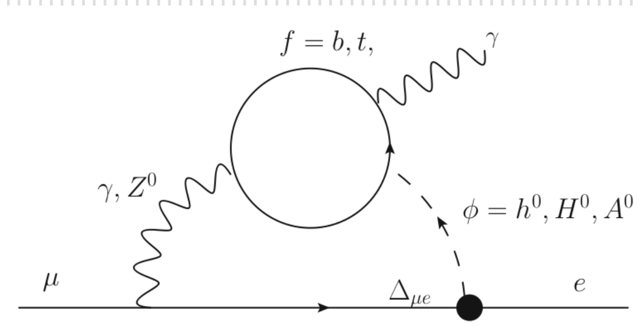
Gaugino LFV



!

$\ll$

Higgs LFV



The Higgs mediated LFV

Higgs mediated FCNC

- In the SUSY model, Superpotential must be holomorphic.

$$W_{\rm MSSM} = Y_u U^c Q H_2 - Y_d D^c Q H_1 - Y_e E^c L H_1 + \mu H_1 H_2$$

SUSY → $\bar{e}_{Ri} Y^e_{ij} e_{Lj} H^0_d$ → 1 Higgs for 1 fermion

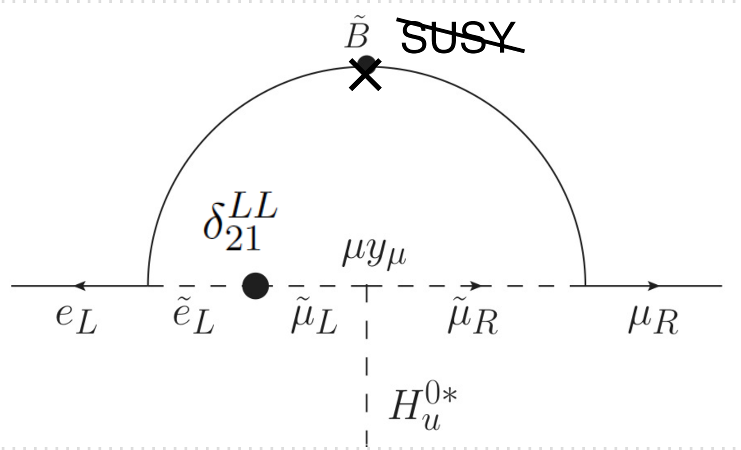
→ no FCNC in the Higgs sector

But, ~~SUSY~~ → $\bar{e}_{Ri} \Delta_{ij} e_{Lj} H^{0*}_u$ → 2 Higgs for 1 fermion

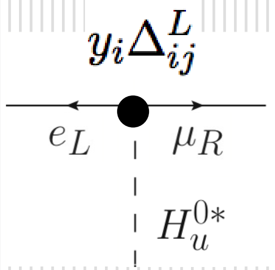
→ off diag Yukawa & FCNC occurs radiatively

Higgs mediated LFV in the MSSM

- LFV Yukawa int. is induced radiatively.



Babu, Kolda (2000,2002)



$$\bar{e}_{Ri} y_i \Delta_{ij}^L e_{Lj} H_u^{0*}$$

Assuming all the SUSY mass are degenerate :

$$\Delta_{21}^L \sim \frac{\alpha_2}{24\pi} \delta_{21}^{LL}$$

independent to M_{SUSY} in first order

⇒ Although SUSY particles mass (M_{SUSY}) is large, this effects remains (non decoupling effects).

Set up of the study

The Non universal Higgs Model (NUHM)

quark	q	1/2	spin	0	squark	$\tilde{q}$	m_0
lepton	l	1/2		0	slepton	$\tilde{l}$	m_0
gauge boson	A_μ	1		1/2	gaugino	λ	$m_{1/2}$
m_{H_u} Higgs boson	H_u	0	μ	1/2	Higgsino	$\tilde{H}_u$	
m_{H_d}	H_d		m_{A^0}	By EWSB condition;		$\tilde{H}_d$	

And we assume either left or right handed flavor mixing;

$$(m^2_{\tilde{e}_L})_{ij} = m^2_{\tilde{e}_L}(\mathbf{1} + \delta^{LL}_{ij}) \qquad (m^2_{\tilde{e}_R})_{ij} = m^2_{\tilde{e}_R}(\mathbf{1} + \delta^{RR}_{ij})$$

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Free parameter

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SUSY seesaw

$$(m^2_{\tilde{e}_R})_{ij} = m^2_{\tilde{e}_R}(\mathbf{1} + \delta^{RR}_{ij})$$

SUSY SU(5) GUT

Set up of the study

The Non universal Higgs Model (NUHM)

m_0

$m_{1/2}$

m_{H_u}

m_{H_d}

quark	q	1/2	spin	0	squark	$\tilde{q}$
lepton	l	1/2		0	slepton	$\tilde{l}$
	H_d		m_{A^0}	condition;		H_d

We discussed μ-e transition
from the gaugino / Higgs effects.

And we assume either left or right handed flavor mixing;

$$(m^2_{\tilde{e}_L})_{ij} = m^2_{\tilde{e}_L}(\mathbf{1} + \delta^{LL}_{ij}) \qquad (m^2_{\tilde{e}_R})_{ij} = m^2_{\tilde{e}_R}(\mathbf{1} + \delta^{RR}_{ij})$$

SUSY seesaw

SUSY SU(5) GUT

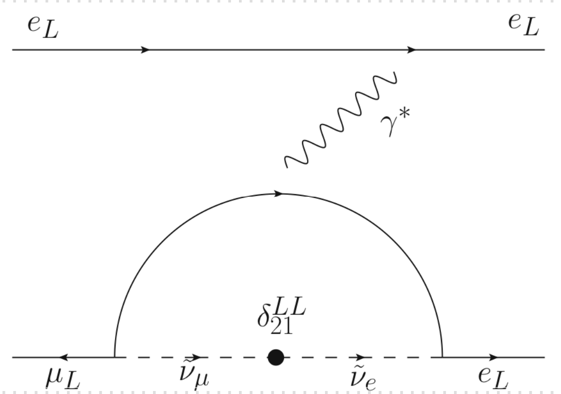
Correlation between μ - e conversion

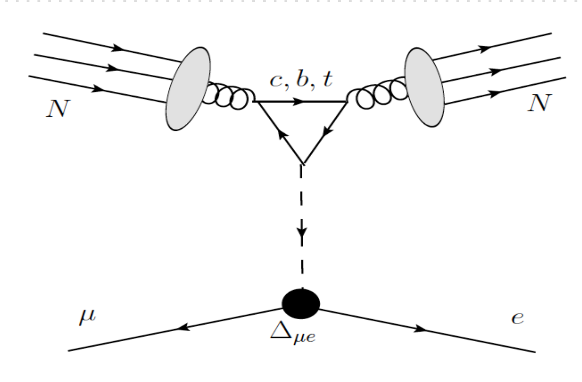
- Evaluate BR(μAl→eAl) / BR(μ→eγ) in some mass parameters.

Gaugino LFV

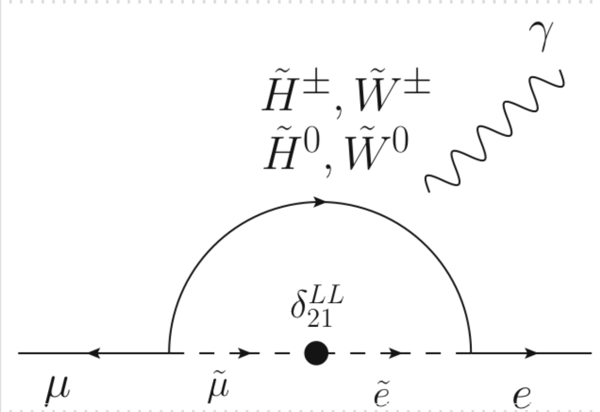
Higgs LFV

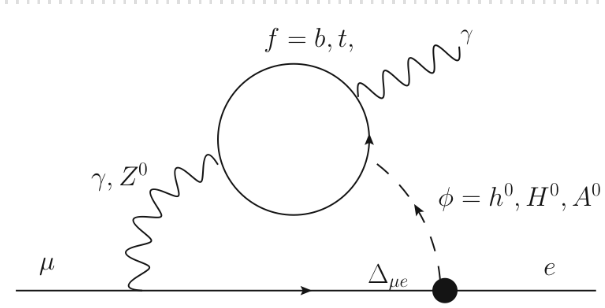
μ Al → e Al





$\mu \to e\,\gamma$



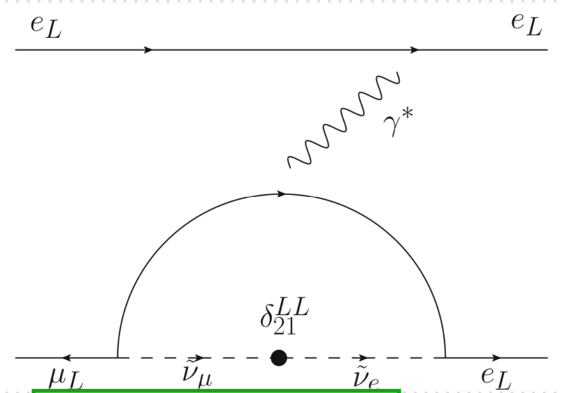


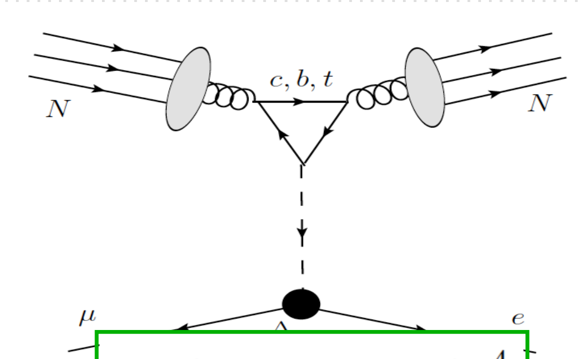
Correlation between μ - e conversion

- Evaluate BR(μAl→eAl) / BR(μ→eγ) in some mass parameters.

Gaugino LFV	Higgs LFV

μ Al → e Al



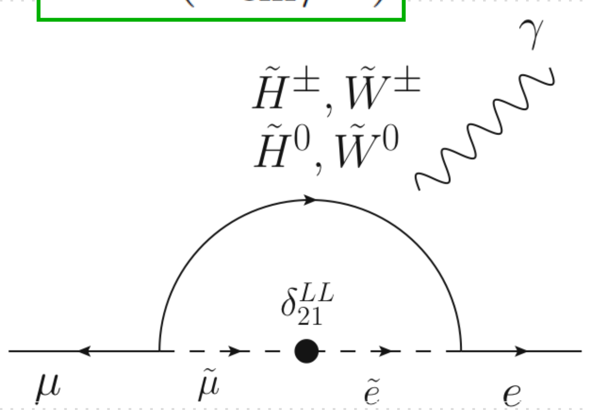


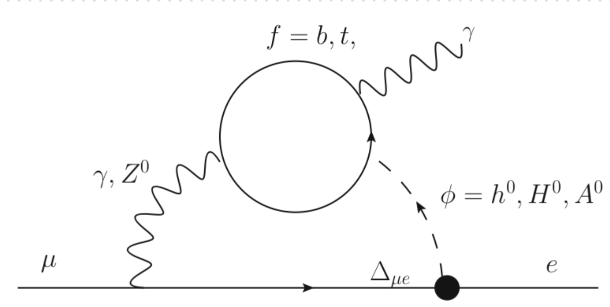
$$\frac{\mathrm{BR}(\mu\mathrm{Al} \to e\mathrm{Al})}{\mathrm{BR}(\mu \to e\gamma)}$$

$$\simeq O(\alpha_{\rm em}/\pi)$$

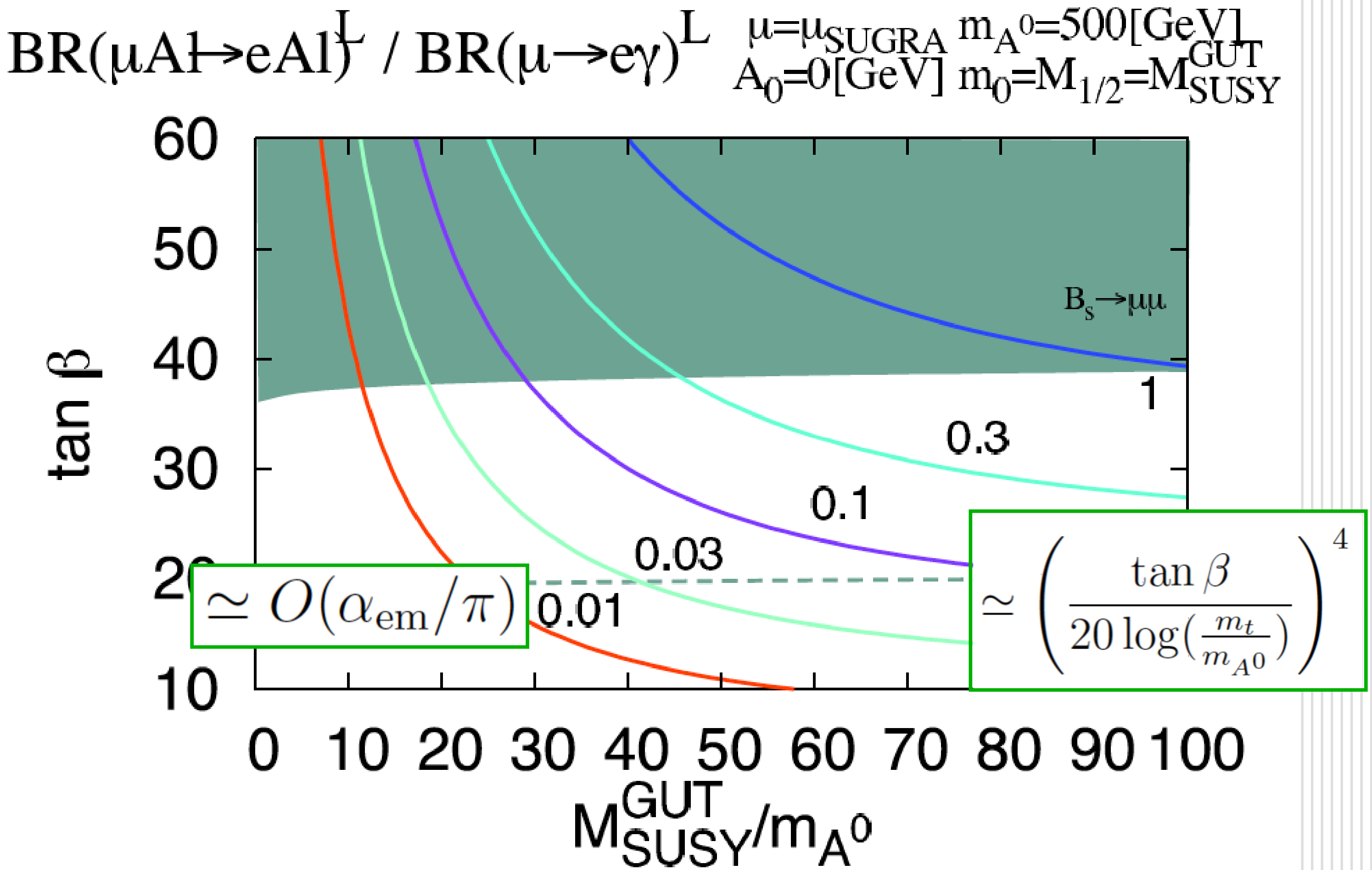
$$\simeq \left(\frac{\tan\beta}{20 \log(\frac{m_t}{m_{A^0}})} \right)^4$$

$\mu \to$ e γ



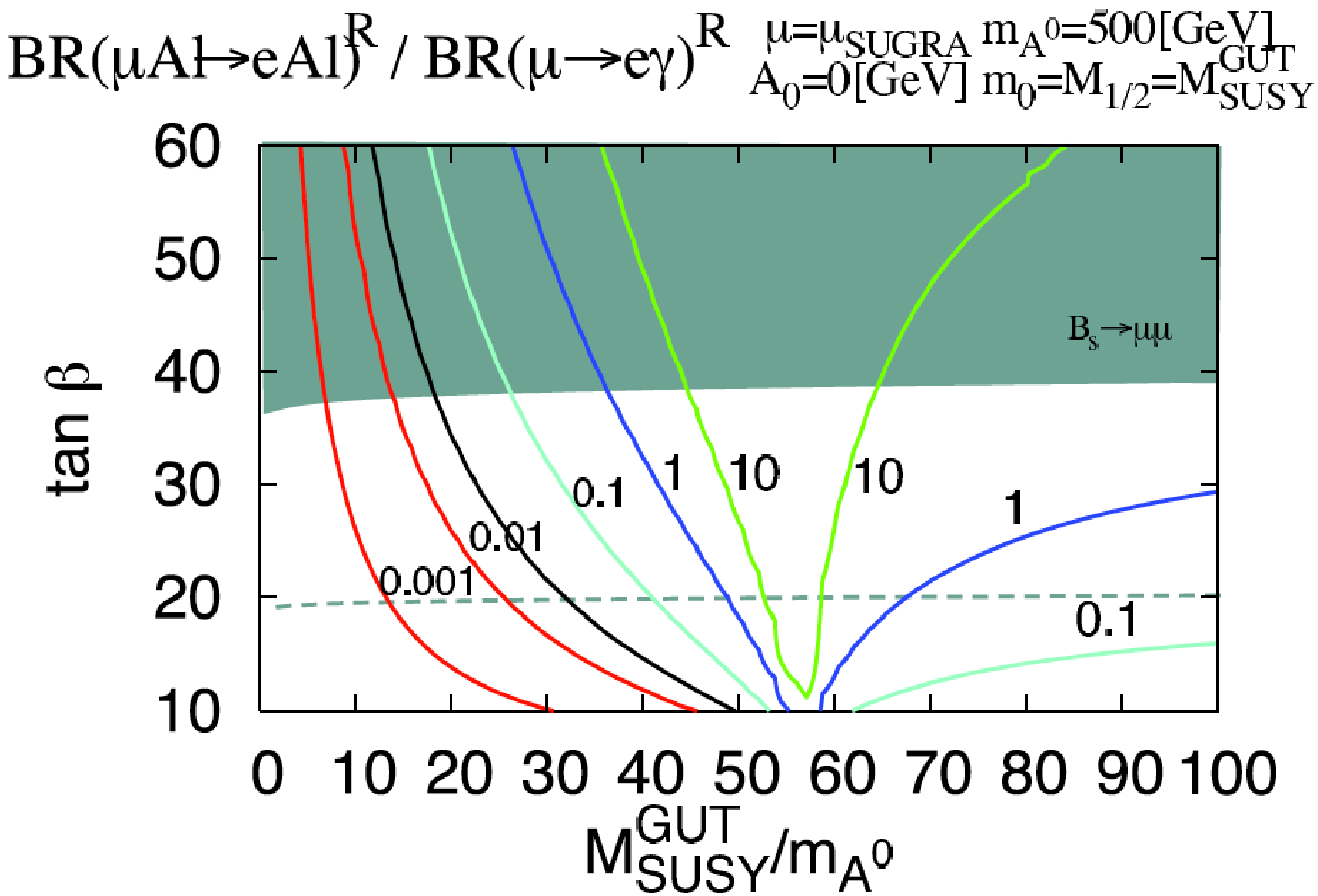


Left handed slepton mixing case



cLFV correlation gives information of Higgs and SUSY sector.

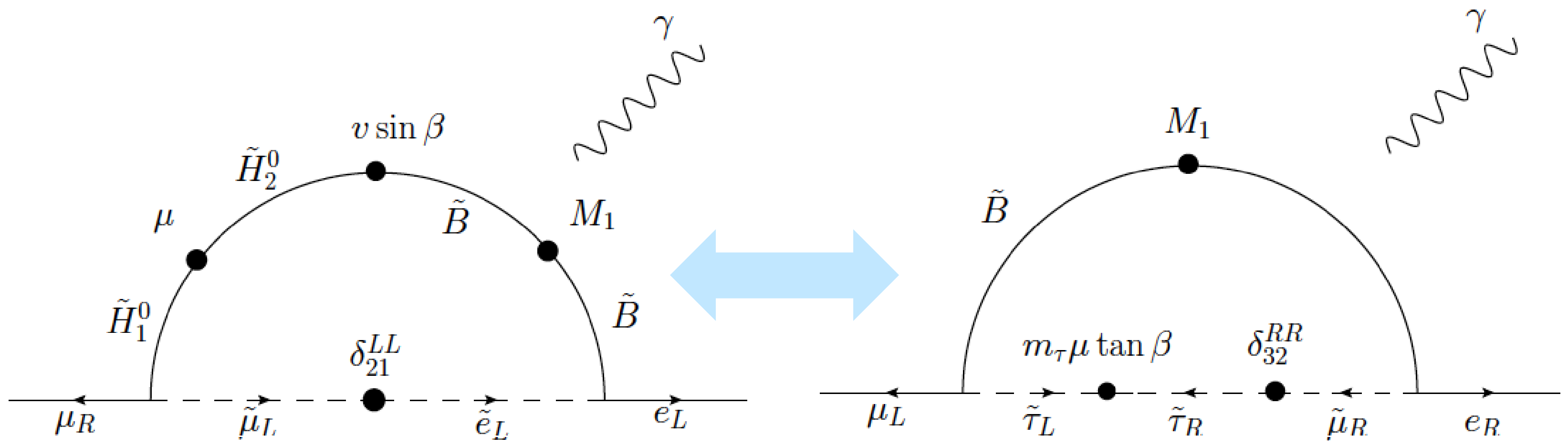
Right handed slepton mixing case



Cancellation structure is different from left-handed mixing case.

Right handed slepton mixing case

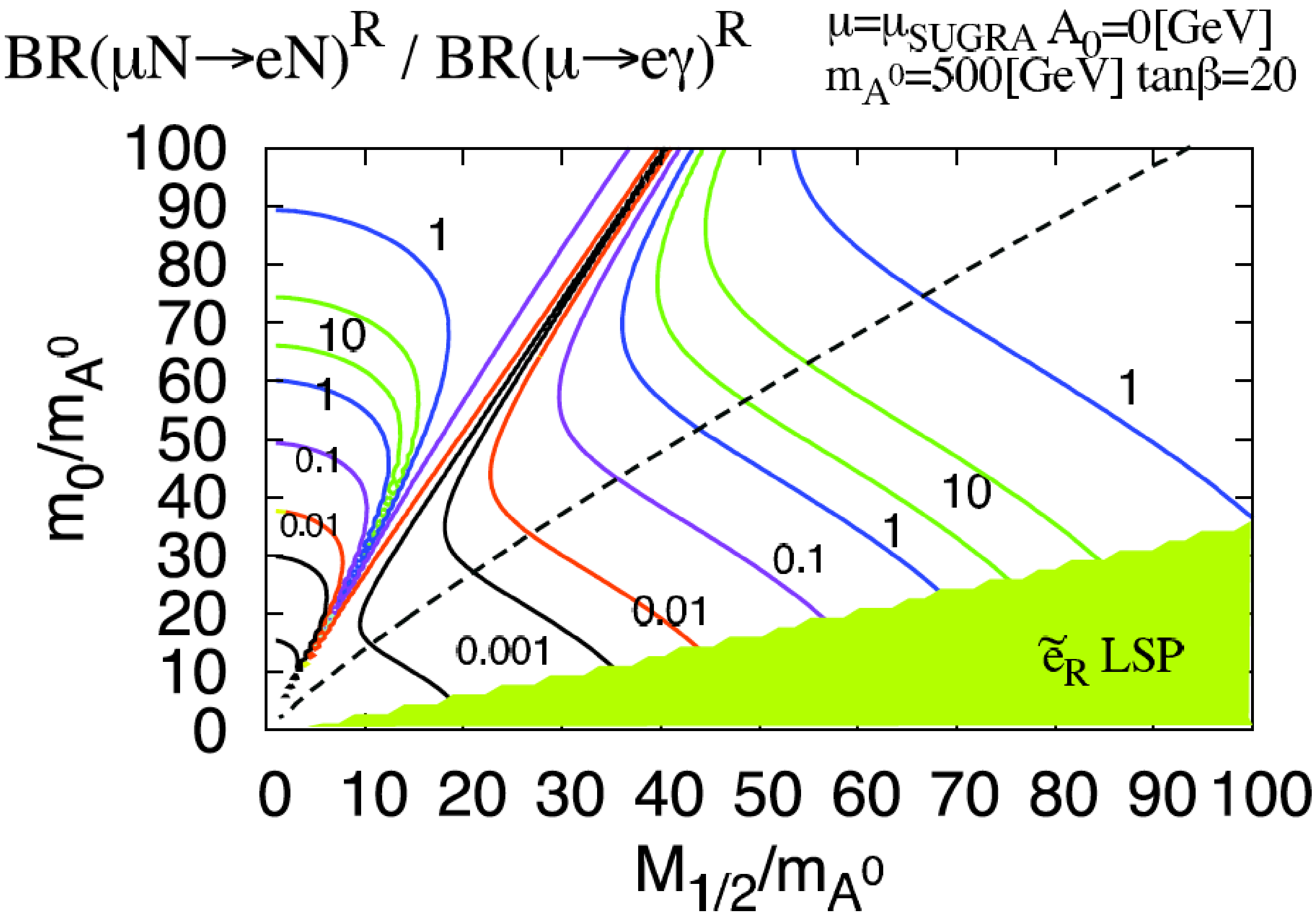
- When only $\tilde{e}_{Ri}$ have flavor mixing, there are cancellation in the μ→eγ process.



Always destructive (Hisano, Moroi, Tobe, Yamaguchi)
and complete cancel when $\mu \simeq \tilde{m}_L$

Right handed slepton mixing case

- When only $\tilde{e}_{Ri}$ have flavor mixing, there are cancellation in the $\mu \to e\gamma$ process.



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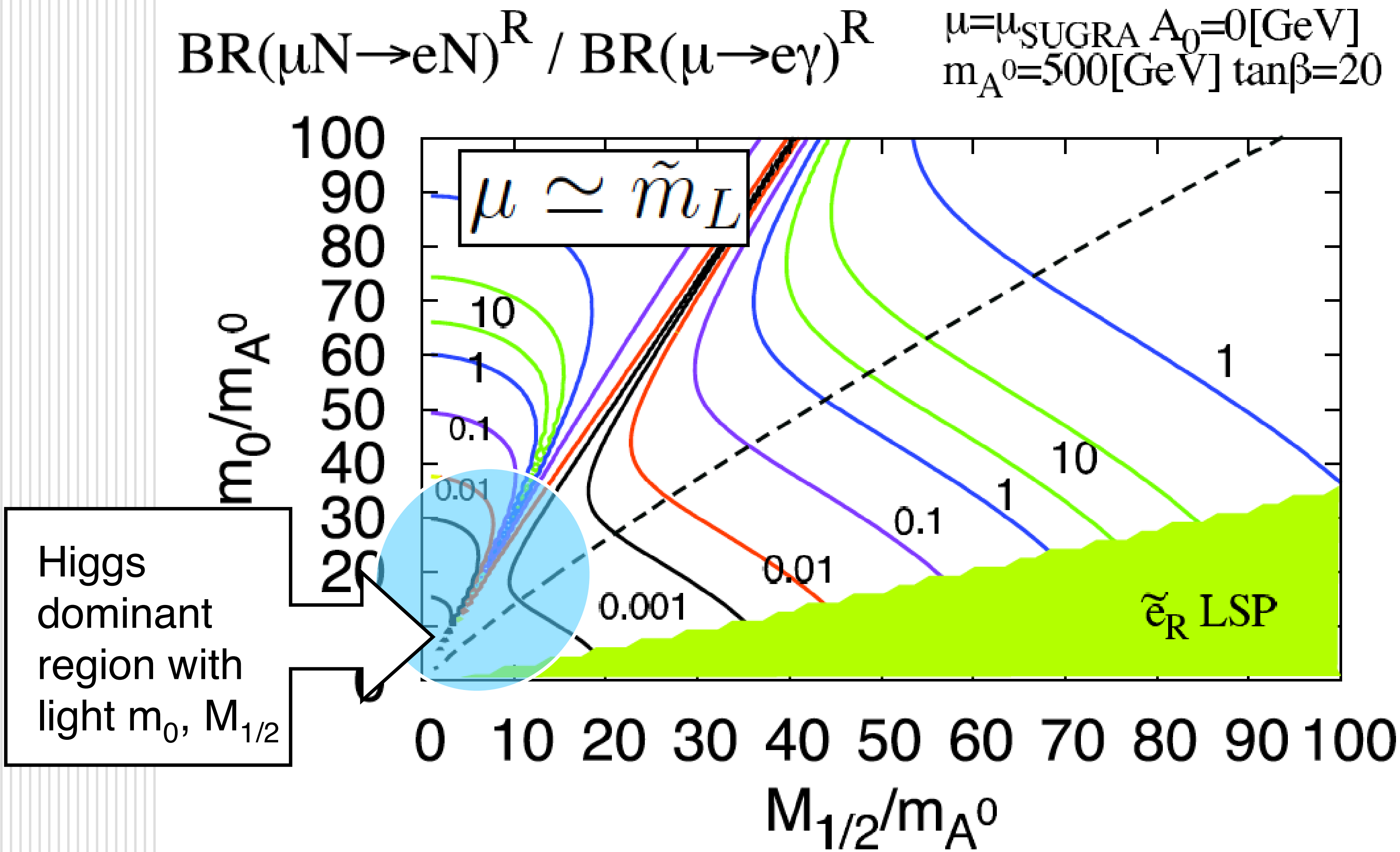

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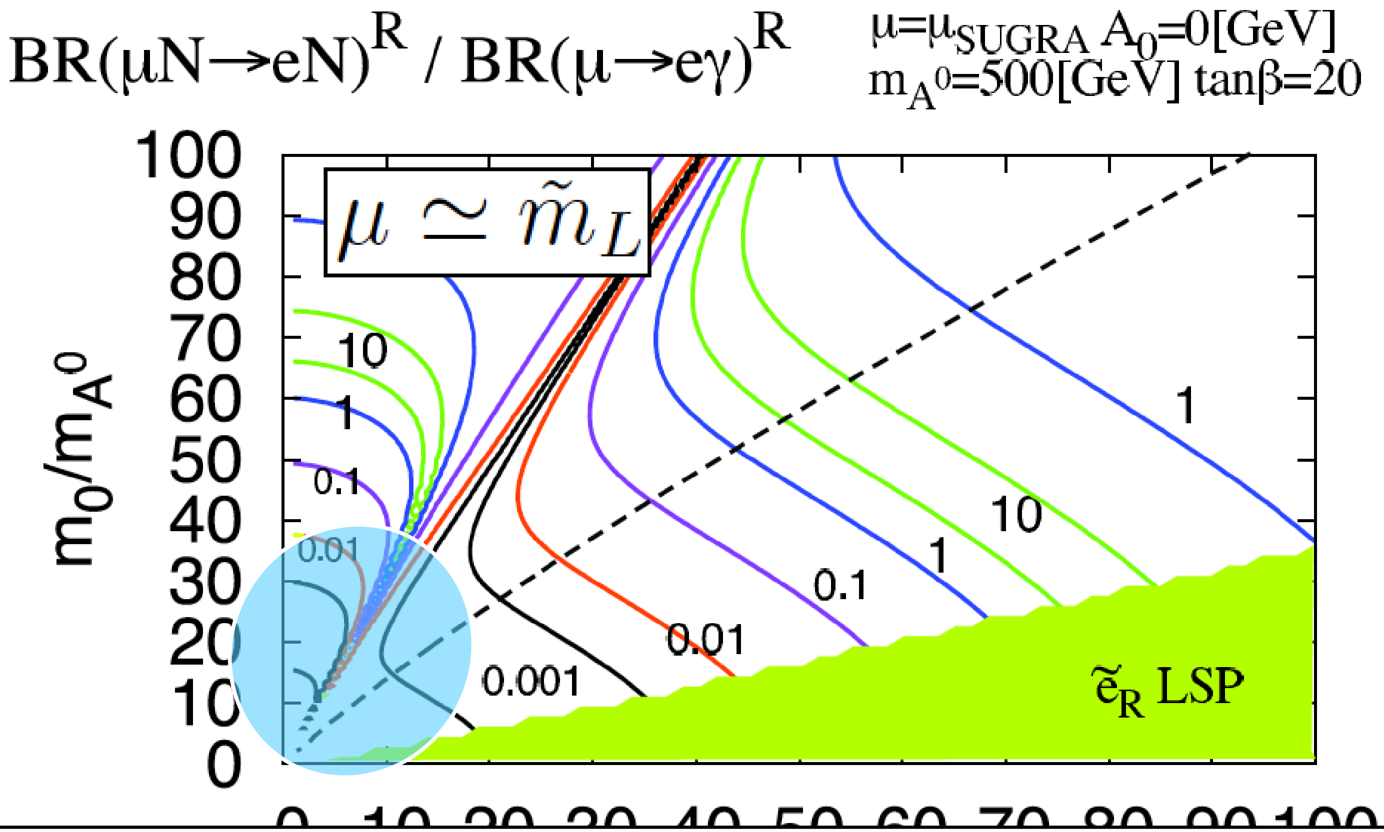

Although m_0 and $M_{1/2}$ are small, the ratio deviates sizably from $O(\alpha)$.

Conclusion

- □ We study non-decoupling μ-e transition effects by Higgs-mediated contribution in the MSSM.

- □ It is considered that the Higgs effect becomes dominant when SUSY particles are decouple. However, there are some Higgs dominant region although SUSY particle masses are TeV scale.

- □ $\mathrm{BR}(\mu N \to eN)/\mathrm{BR}(\mu \to e\gamma)$ could constrain $tan\beta$, m_A, or M_{SUSY}. The cLFV correlation gives information of Higgs sector or SUSY sector.

That's all.

Thank you.